

Evaluating agency use of “best available science” under the Endangered Species Act

Natalie C. Lowell

A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Marine Affairs

University of Washington

2015

Committee:

Ryan P. Kelly

Beth Bryant

Program Authorized to Offer Degree:

Marine Affairs

©Copyright 2015

Natalie C. Lowell

University of Washington

Abstract

Evaluating agency use of “best available science” under the Endangered Species Act

Natalie C. Lowell

Chair of Supervisory Committee:
Assistant Professor Ryan P. Kelly, PhD., J.D.
School of Marine and Environmental Affairs

Since Congress passed the Endangered Species Act (ESA) in 1973, the world’s population has nearly doubled, environmental issues have become increasingly politicized, and species continue to go extinct at alarming rates, leading to political conflict that potentially impedes ESA implementation. Because the ways in which agencies use science in the ESA often serve as the legal basis for litigation, it is timely and pertinent to evaluate the quality of science used, both in order to point to ways of improving ESA science policy and to minimize agency exposure to future litigation. The “best” available science and its use are each moving targets, difficult to define in the abstract. However, a straightforward way of evaluating these ideas is to

compare the use of science by each of the two administrative agencies in charge of implementing the ESA, the Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA). Here, I use a suite of data sources—including litigation records, authorship affiliation, and bibliography and listing frequency data—to ask whether one agency systematically uses “better” science than the other. I find that the NOAA outperforms the FWS on four of eight metrics, while the agencies do not differ by the remaining four metrics, suggesting that, overall, the NOAA uses systematically better science than FWS. Lastly, I interpret my findings in the context of each agency's budget, structure, and history and highlight specific policy mechanisms that would allow the agencies to use better science and improve endangered species management.

Table of Contents

List of Tables and Figures.....	i
Acknowledgements	ii
Introduction	1
The Endangered Species Act and “Best Available Science”	1
Comparing the FWS and the NOAA	4
Methods.....	5
Results	10
Authorship Index	10
Litigation Records	11
BiOp Bibliographies	11
Annual Listing Frequency	13
Discussion	15
NOAA Outperforms FWS.....	15
Differences in Agency Budget, Structure, and History	18
Policy Recommendations	19
Conclusion.....	21
Literature Cited	22

List of Tables and Figures

Table 1: Summary of results comparing the FWS and the NOAA.....	10
Figure 1: Authorship index by agency jurisdiction	11
Figure 2: Length of BiOp bibliographies by agency jurisdiction.....	12
Figure 3: Skewed distribution of EF values and comparison of mean log-transformed EF values by agency jurisdiction	12
Figure 4: Proportion of sources with EF values by agency jurisdiction	13
Figure 5: Annual listing frequency by agency jurisdiction	14

Acknowledgements

I am grateful for the creative academic community at the School of Marine and Environmental Affairs, particularly Ryan Kelly and my thesis advising group peers. Their support made my graduate school experience both productive and enjoyable. And, I am grateful to Beth Bryant, Jameal Samhouri, and Mark Eames for feedback on thesis drafts and to James O'Donnell for statistical support.

Introduction

Congress passed the Endangered Species Act (ESA) of 1973 (16 U.S.C. § 1531 et seq.) decades before we knew the scale of the extinction problem. Now, with an improved understanding of global anthropogenic impact, Earth appears to be heading toward the largest mass extinction since the Cretaceous-Tertiary event 65 million years ago (Barnosky et al, 2011; McCauley et al, 2015). In addition, environmental issues have become increasingly politicized since the mid-1990's (Elliott, 2008; Doremus, 2001), leading to growing political conflict over the ESA: those attacking the ESA for over-protecting listed species at the expense of private property rights, and those attacking the ESA for under-protecting those same species at the risk of losing them entirely (Buck et al., 2006). Given that these political pressures may threaten the ESA's function as a tool to protect species from the risk of extinction (Doremus, 2001), ensuring that the implementing agencies continue to use objective, externally validated methods to carry out the ESA's aims seems increasingly important.

The Endangered Species Act and “Best Available Science”

The ESA aims to “provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved” and to “provide a program for the conservation of such endangered species and threatened species,” (16 U.S.C. § 1532). Two agencies administer the ESA, the Fish and Wildlife Service (FWS; within the Department of the Interior) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA; within the Department of Commerce). These agencies share core implementation responsibilities but differ in species jurisdiction: with few exceptions, the FWS manages terrestrial and freshwater species and the NOAA manages marine species. The major

steps of implementation include evaluating and, if warranted, listing a species as threatened or endangered (ESA §4, codified at 16 U.S.C. § 1533(a)(1)), designating critical habitat for each listed species (§4, codified at 16 U.S.C. § 1533(a)(3)), writing Recovery Plans (§4, codified at 16 U.S.C. § 1533(f)), and consulting with other federal agencies that may “jeopardize the continued existence” of listed species (§7, codified at 16 U.S.C. § 1536).

As a check on agency discretion in carrying out the Act, Congress required the agencies use science to guide decisions at the key steps of ESA implementation. This call to use the “best available science” was the first in modern federal conservation legislation (Doremus, 2001), although requiring administrative decision-making to be rooted in rational reasoning was not new in the 1970’s: the Administrative Procedure Act of 1946 established standards of judicial review to ensure that agency regulations are not “arbitrary and capricious” (5 U.S.C. § 701 et seq.). The science mandate explicitly extends to three sections of the ESA: critical habitat designation (§4) and agency consultation (§7) must be based on the “best scientific and commercial data available,” and scientific and commercial data must be the only considerations for listing decisions (§4). Observers often refer to these requirements, collectively, as the “best available science” (BAS) mandate (Doremus, 2004), a term I use throughout this paper.

The ESA does not explicitly define BAS, nor is there a publically available administrative definition (Doremus, 2004). As a result, it is never obvious what constitutes BAS in any particular situation, and moreover, the two implementing agencies may diverge in their practices surrounding BAS. The FWS and NOAA issued a cooperative policy statement in 1994 concerning information standards under the ESA (USFWS & NOAA Fisheries, 1994) that elaborated on BAS, but focused largely on procedure for using science and not defining BAS science itself.

Consequently, what constitutes BAS is often necessarily left to agency discretion (*Miccosukee Tribe of Indians of Fla. V. United States*, 2009), and ultimately settled in court following litigation (Baur & Irvin, 2010). It then follows that the ways in which the agencies and courts have defined BAS are context-specific. For example, in *Protect our Communities Foundation v. Ashe*, the distinguishing feature of BAS was the variety of data types used to establish a project's noise and visual impacts on Peninsular Bighorn sheep (2013). In *Greenpeace American Oceans Campaign v. National Marine Fisheries Service*, telemetry data describing foraging areas of Steller sea lions constituted BAS, even though the telemetry tells of location and not behavior (2000). However, because behavior observation data delineating specific foraging areas was not available, telemetry data served as the best approximation of where the sea lions foraged. Hence an all-purpose definition of BAS does not exist, but taken together, judicial decisions make clear in practice BAS is grounded in widely accepted hallmarks of good science—such as peer-review, replication, and a thorough literature review (Buck et al., 2006; Baur & Irvin, 2010).

Previous research has evaluated agency use of science in ESA implementation. In 1998, authors from the Society for Conservation Biology (SCB) reviewed Recovery Plans for listed species under the ESA in order to gauge the scientific caliber of the Recovery Plan management objectives (Gerber & Schultz, 2001). To do so, the authors sent a detailed questionnaire to academic scientists from 19 universities to evaluate FWS Recovery Plans, found that diverse authorship affiliations in Recovery Plans correlated with improved use of biological information in the management objectives that conclude the plans. This finding aligns with the broader scientometrics literature that suggests collaboration and membership diversity in authorship increase the opportunities for knowledge creation and often research quality in academic (Liao,

2010; Eaton et al., 1999) and research agency settings (Goldfinch et al., 2003). Another study found that ESA Recovery Plan approval and listing decision frequencies for Republican administrations were significantly lower than for Democratic administrations, highlighting the interaction of politics and science, and suggesting that non-scientific factors can dominate ESA decisions (Stinchcombe, 2000). Notably, these studies pre-date the G.W. Bush (Bush) administration years, an administration of interest for ESA science policy research due to its perceived anti-ESA nature (Lambright, 2008; Jennings & Hall, 2012; Gehring & Ruffing, 2008; Doremus & Tarlock, 2005).

Comparing the FWS and the NOAA

Agencies that share regulatory space—such as the FWS and NOAA sharing ESA implementation responsibilities—act as replicate “laboratories” of agency behavior, using different methods to achieve similar goals and ideally learning from each other’s successes and errors (Freeman & Rossi, 2012). Here, I aim to use the contrast between agency behavior to identify better and worse practices surrounding the use of science in policy. To the extent that one agency systematically uses science more effectively than the other, I can identify implementation gaps and point toward improved science use.

Whether the agencies can benefit from this study depends on my ability to detect differences in the quality of science used and on whether the proper interagency structure for coordination and learning exists. The FWS and NOAA have not always acted consistently with the BAS mandate, as is demonstrated in their litigation records. For example, the agencies lose on BAS grounds in court on occasion (see *Intertribal Sinkyone Wilderness Council v. National Marine Fisheries Service*, 2013, and *Center For Native Ecosystems v. US Fish and Wildlife Service*, 2011). This suggests that the quality of science use at the agency level varies. And the

agencies have already demonstrated interagency infrastructure for such agency learning by coordinating to jointly manage species under their shared jurisdiction and issuing Memoranda of Understanding and joint Cooperative Policy Statements (NOAA, 2015). Together, these ideas suggest that I may find a difference in quality of science used and that the agencies can benefit from such analysis.

Although no single metric can be used to qualify science as “good” or “bad”, using several and disparate metrics will allow me to triangulate whether one agency systematically uses better science than the other. I compare the quality of science used by the FWS and NOAA with multiple data types, metrics rooted in hallmarks of good science, and by building on previous research. I use Recovery Plan authorship data, litigation records, Biological Opinion (BiOps, the reports produced during the Section 7 consultation process; 16 U.S. Code § 1536) bibliographies, and annual listing frequency data to compare the agencies.

Methods

First, I quantified the affiliation diversity of authors listed on ESA Recovery Plans. Whereas the previous authorship-diversity study limited its scope to species under FWS jurisdiction (Gerber & Schultz, 2001), I used the same methods to evaluate authorship affiliation diversity of Recovery Plans under FWS, NOAA, and joint FWS-NOAA jurisdictions. These methods entail categorizing each author of each document into one of the following designations: FWS or NOAA, other federal agencies, state resource agencies, other state agencies, local government agencies, tribal groups, business or industry, environmental or conservation organizations, consultants, academia, and the general public. The authorship index is the number of different categories represented by the authors (i.e., richness). My null

hypothesis was that the authorship index of Recovery Plans under FWS, NOAA, and shared jurisdiction would not differ significantly. I used a Kruskal-Wallis to identify overall differences in authorship index and Dunn's test to identify pairwise differences in authorship index between agency jurisdictions. If the agencies differ, I would interpret a greater diversity of authorship affiliation as being more closely aligned with using the BAS.

Second, I compared the proportion of lawsuits that each agency lost on BAS grounds. To do so, I used the Westlaw database (2015) to collect all judicial opinions from cases with the following search query: either FWS or NOAA was a party in the case, "best available sci*" appeared in the text (to find either the statutory mandate, "best available scientific and commercial data" or the simplified phrase, "best available science"), and "Endangered Species Act" appeared in the text. I read each case and only considered cases where BAS under the ESA was among the grounds for litigation. I marked those as a "loss" where the court decided the case on its merits, holding that the agency failed to use the best available science under the ESA, and marked cases as a "win" where the court concluded the opposite. If a court decided that the agency was not using the best available science under the Marine Mammal Protection Act (MMPA) or Magnuson-Stevens Act—two other Acts with BAS mandates—I did not count it as a "loss" for the agency, because my focus here is specifically on ESA implementation. The proportion of cases lost is the number of "losses" divided by the sum of "losses" and "wins". My null hypothesis was that the agencies would not differ significantly in the proportion of cases lost. If the agencies differ, I would interpret the agency losing a smaller proportion of cases as being more closely aligned with using the BAS.

Third, I compared the length of BiOp bibliographies between the agencies, given that a thorough literature review is a hallmark of good science (Buck et al., 2006). My null hypothesis

was that the agencies would not differ significantly in the length of BiOp bibliographies. If the agencies differ, I would interpret the agency with longer bibliographies as being more closely aligned with using the BAS.

Fourth, I categorized information source types in BiOp bibliographies using a framework developed by Jennings and Hall for measuring the weight agencies place on scientific studies and formal evaluations in relation to other information source types (2012), and tested for differences in information type composition. In addition to the four major categories set forth in the framework (scientific/professional, agency, innovation, and political) I adapted the Jennings and Hall framework to the context of BiOps, adding categories for regulation, personal communications, tribal organization, and unknown (the vast majority of sources fell into the original framework's categories). Because a significant difference in the reliance on scientific/professional information sources would be secondary to a difference in overall information source type composition, my null hypothesis was that the agencies would not differ significantly in overall information source type composition. I used a PERMANOVA to test for differences in information type composition (Oksanen et al., 2007). If the agencies differ, I would interpret the agency using more scientific/professional sources as being more closely aligned with using the BAS.

Fifth, for each scientific journal reference in the BiOp bibliographies, I used Eigenfactor.org to calculate the Eigen Factor (EF) value, a journal impact factor that adjusts for citation differences across disciplines and makes use of the entire citation network to approximate importance of a journal (West et al., 2010). I compared the mean log-transformed EF values in bibliographies between the agencies, with the notion that better science often appears in journals with higher impact. Log-transformation was appropriate because the

distribution of EF values is highly skewed. My null hypothesis was that the agencies would not differ significantly in the mean log-transformed EF values for BiOp bibliographies. If the agencies differ, I would interpret the agency using higher log-transformed EF values in bibliographies as being more closely aligned with using the BAS.

Sixth, I compared the proportion of journal articles with an EF value in BiOp bibliographies as a proxy for the proportion of high-quality journal articles, because the EF values are generated using the Thomson Reuters database, which includes reputable and well-established journals across many disciplines (Testa, 2012). Moreover, the categorization of science in the Jennings and Hall framework (2012) extends to multiple source types that may not be peer-reviewed. Thus, the proportion of EF sources also reflects the amount of peer-reviewed content, another hallmark of good science (Buck et al., 2006). I calculated the proportion of scientific journal articles with EF values and compared proportions between the agencies. My null hypothesis was that the agencies would not differ significantly in the proportion of scientific journal articles with EF values in bibliographies. If the agencies differ, I would interpret the agency using a greater proportion of EF sources to be more closely aligned with using the BAS.

Seventh, because listing decisions are to be based “solely on the best available scientific and commercial data” (ESA§7), listing decisions are theoretically independent of politics. Building on work by Stinchcombe (2000), I compared the annual listing decision frequencies between Republican and Democratic administration years and, as an additional eighth metric, between Bush and non-Bush administration years. To do so, I collected listing decision data from the Electronic Code of Federal Regulations Endangered Species List as of February 1, 2015, excluding delisting, emergency rules, and corrections to decisions (that are listed as decisions) (Title 50 e-C.F.R § 17.11). I excluded data before 1980 because the initial years of the ESA were

characterized by stochastic annual listing frequencies, likely due to the agencies adjusting to their new function (Florino, 2001) and the new burden of listing the numerous species in need of protection that sparked the passage of the ESA. Moreover, environmental issues were not yet as predictably partisan before 1980 (Klyza & Sousa, 2008, p. 20), and scholars suggest that the extreme politicization of environmental issues began in 1990 (Klyza & Sousa, 2008; Jennings & Hall, 2012). Thus, I would not expect an effect of political administration before 1990, much less before 1980. The rationale for highlighting the Bush years, in particular, comes from legal scholars' descriptions of the Bush administration as especially anti-ESA, making these years of particular interest (Lambright, 2008; Jennings & Hall, 2012; Gehring & Ruffing, 2008; Doremus & Tarlock, 2005). My null hypotheses were that the annual listing frequencies of both agencies combined would not differ between Republican and Democratic administration years or between Bush and non-Bush administration years. I also hypothesized that the agencies' annual listing frequencies, taken separately, would not differ between Republican and Democratic administration years or between Bush and non-Bush administration years, and that the magnitude of the difference in listing frequencies due to political administration change would not differ between the agencies. To do this, I scaled each agency's data set to the total number of listing decisions each agency accrued from 1980 to 2014. If the agencies differ, I would interpret the agency less affected by changes in political administration to be more closely aligned with using the BAS.

I used the statistical package R 3.1.2 for all data manipulation, statistical analysis, and figures (R Core Team, 2012).

Results

Table 1 summarizes the results comparing the FWS and NOAA.

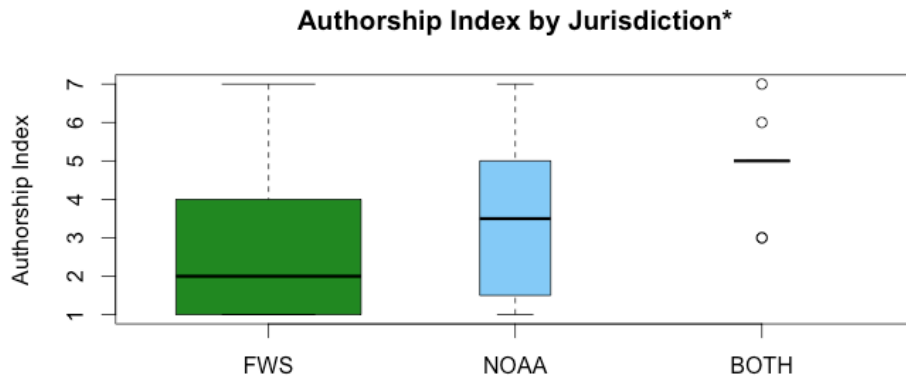
Table 1: Summary of results comparing the FWS and the NOAA. A ">" signifies that the former agency outperformed the latter and "No difference" signifies that no significant difference was detected between the agencies with the metric.

Metric	Data Source	Science Use
Authorship index	Recovery Plans	NOAA > FWS
Proportion of cases lost on BAS grounds	Federal Judicial Opinions	No Difference
Bibliography length	BiOps	NOAA > FWS
Information source composition of bibliographies	BiOps	No Difference
Mean log-transformed EF values of bibliographies	BiOps	No Difference
Proportion of bibliography sources with EF values	BiOps	NOAA > FWS
Presidential party effect on annual listing decision frequency	Endangered Species List	No difference
Bush administration effect on annual listing decision frequency	Endangered Species List	NOAA > FWS

Authorship Index

The authorship index differed significantly among all jurisdiction groups—FWS, NOAA, and shared FWS-NOAA jurisdiction—when considered simultaneously (Kruskal-Wallis test, p-value = .0047). Authorship richness was significantly higher for plans with shared jurisdiction than for NOAA jurisdiction alone (Dunn’s test, p-value = .0345), and higher for plans with NOAA jurisdiction than for FWS jurisdiction (Dunn’s test, p-value = .003) (Figure 1).

Figure 1: Authorship index by agency jurisdiction. Boxes of boxplots represent the interquartile range and whiskers extend to 1.5 times the interquartile range. The widths of the boxplots are proportional to the square root of the numbers of observations. Circles represent outliers. FWS n = 109, NOAA n = 16, both agencies jurisdiction n = 10.



Litigation Records

The FWS and the NOAA did not differ in the proportion of cases lost (Chi-squared test, p-value = 1, FWS proportion lost = .26, NOAA proportion lost = .27, FWS n = 27, NOAA n = 15).

BiOp Bibliographies

FWS bibliographies cited significantly fewer sources than NOAA bibliographies (Mann-Whitney test, p-value = .0002, mean FWS bibliography length = 73.2 references, mean NOAA bibliography = 241.7 references, FWS n = 25, NOAA n = 25, FWS sd = 71, NOAA sd = 226) (Figure 2). The information-source-type composition did not differ significantly between the agencies (F ratio = 1.6628, p-value = .1858 for 1000 permutations); the top five information source types for both agencies that I was able to categorize were professional science, agency, innovative, personal communication, and political source types, in order of decreasing abundance. The mean log-transformed EF value did not differ significantly between the agencies (Mann-Whitney test, p-value = .5074) (Figure 3, right panel), indicating that the agencies were

citing references of about the same impact in the scientific community. However, the FWS bibliographies had significantly smaller proportions of scientific journal references with EF values than the NOAA bibliographies (Mann-Whitney test, p-value = .0094, mean proportion FWS = .176, mean proportion NOAA = .234, $s = .0899$, $n = 47$) (Figure 4), indicating that FWS relied more heavily on information sources other than scientific journals.

Figure 2: Length of BiOp bibliographies by agency jurisdiction. Boxes of boxplots represent the interquartile range and whiskers extend to 1.5 times the interquartile range. Circles represent outliers.

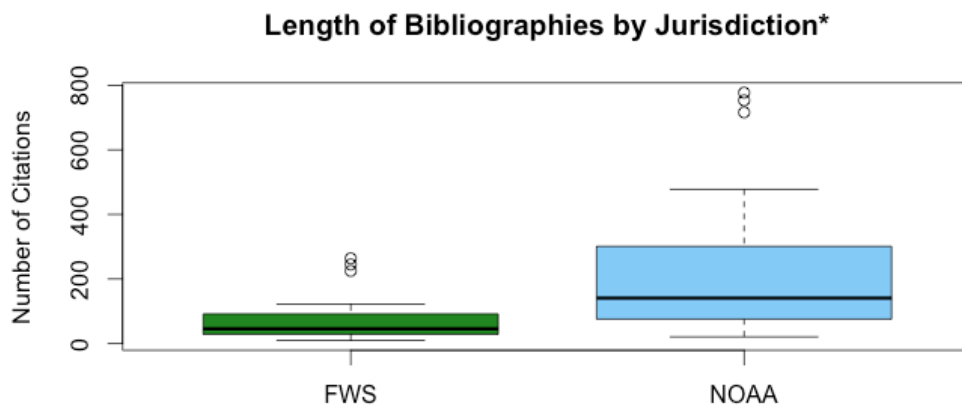


Figure 3: Skewed distribution of EF values (left panel) and comparison of mean log-transformed EF values by agency jurisdiction (right panel).

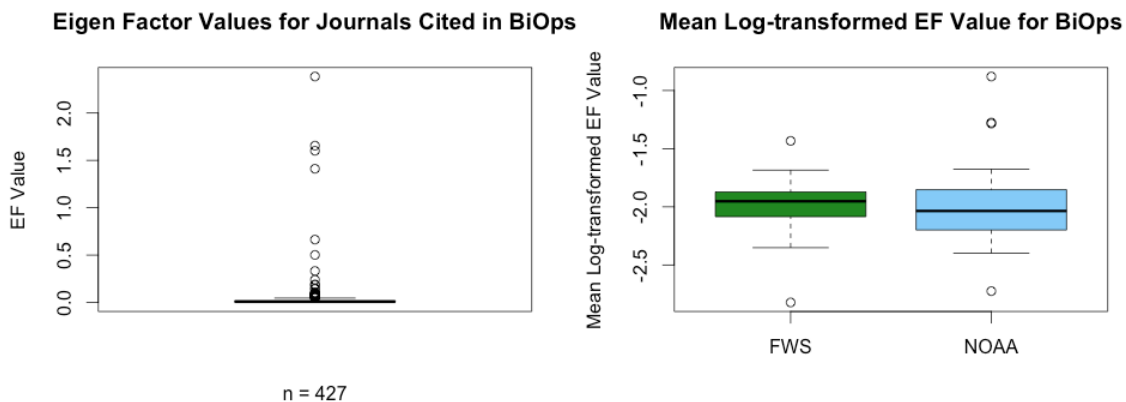
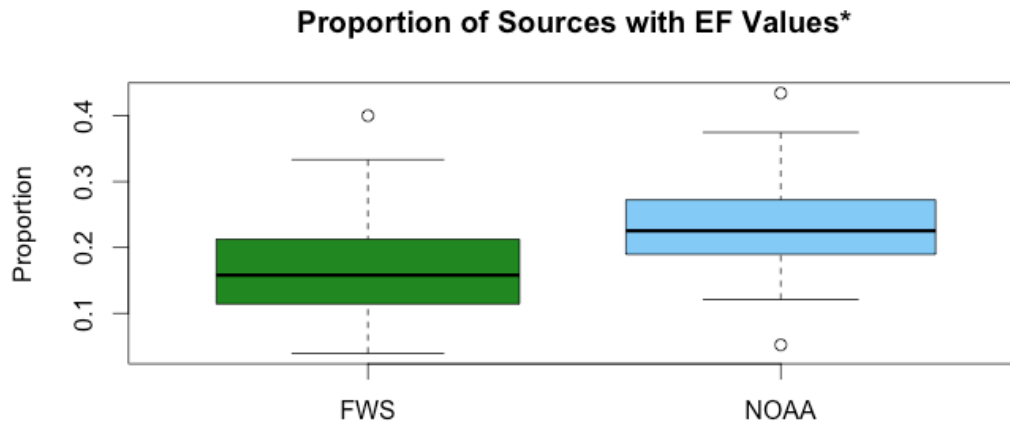


Figure 4: Proportion of sources with EF values by agency jurisdiction. Boxes of boxplots represent the interquartile range and whiskers extend to 1.5 times the interquartile range. Circles represent outliers.



Annual Listing Frequency

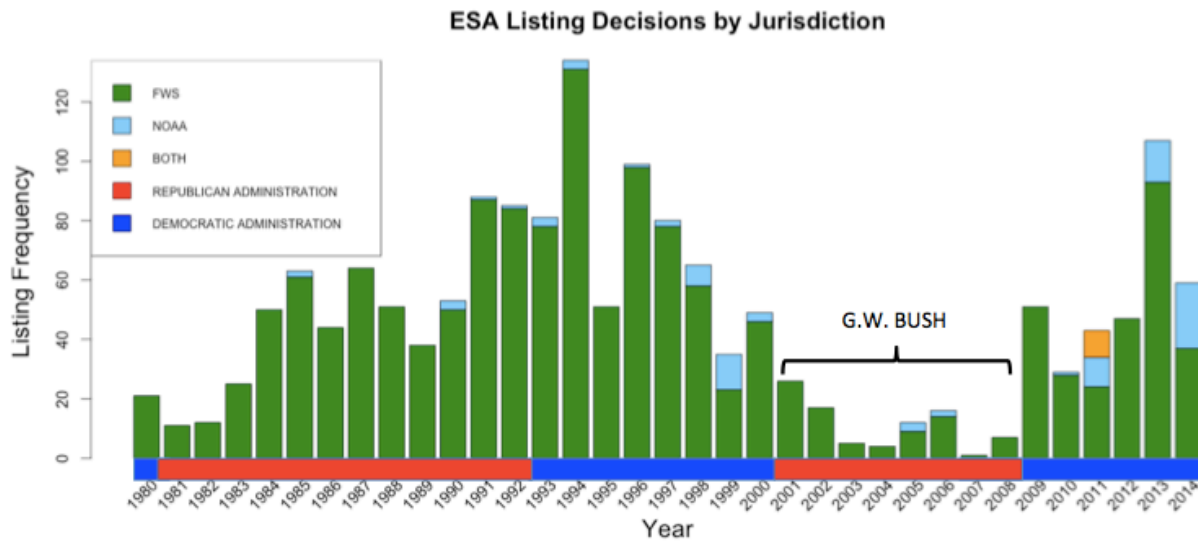
Annual listing decision frequency for both agencies combined was significantly higher during Democratic administration years than Republican administration years (Mann-Whitney test, p-value = .01, mean Republican administration years = 33.6, mean Democratic administration years = 62.8, s = 32.35, n = 35) and during non-Bush administration years than Bush administration years (Mann-Whitney test, p-value = .0001, mean Bush administration years = 11, mean non-Bush administration years = 56.9, s = 31.55, n = 70)(Figure 7).

The FWS annual listing frequencies of Republican administration years were significantly lower than Democratic administration years (Mann-Whitney test, p-value = .024, mean FWS Republican years = 33, mean FWS Democratic years = 57.6). Likewise, the NOAA annual listing frequencies of Republican administration years were significantly lower than Democratic administration years (Mann-Whitney test, p-value = .003, mean NOAA Republican years = .6, mean NOAA Democratic years = 5.2, sd = 4.86, n = 35). Neither agency was more affected by presidential party affiliation (two-way ANOVA, p-value = .053, F value = 14.4).

The FWS annual listing frequencies of Bush administration years were significantly lower than in non-Bush administration years (Mann-Whitney test, p-value = .00001, mean FWS Bush years = 10.4, mean FWS non-Bush years = 53.4, FWS Bush years sd = 8.21, FWS non-Bush years sd = 28.81, Bush years n = 8, non-Bush years n = 27). However, the NOAA annual listing frequencies of Bush and non-Bush administration years were not significantly different (Mann-Whitney test, p-value = .1438, NOAA Bush years sd = 1.18, NOAA non-Bush years sd = 5.38, NOAA Bush years n = 8, NOAA non-Bush years n = 27).

Annual listing frequencies for both agencies and for species with shared agency jurisdiction are represented in Figure 5.

Figure 5: Annual listing frequency by agency jurisdiction. Red and blue bars constitute a timeline of presidential administration party. The Bush administration is noted separately with a horizontal bracket.



Discussion

NOAA Outperforms FWS

The benefit of multiple agencies executing the same law in different ways is the ability to evaluate those differences, learn from them, and evolve best practices. In this paper, I compared the quality of science used between the FWS and NOAA under ESA implementation in order to identify potential differences in science use. Out of eight metrics, four demonstrated the NOAA using better science than the FWS and four demonstrated no significant difference (Table 1). Because the NOAA outperformed the FWS on four metrics and the FWS outperformed the NOAA on none, I suggest that the NOAA systematically uses better science than the FWS.

Moreover, the BAS mandate does not explicitly extend to Recovery Plans in the text of the ESA (16 U.S.C. § 1534(f)). Therefore, the outcome that the NOAA uses a greater diversity of authors in Recovery Plans than the FWS may shed light on a deep difference in the agencies such as their culture or structure, leading to the NOAA using better science even where it is not legally mandated.

Although most metrics speak to the quality of science used, not all metrics speak directly to how well the science is used in ESA decision-making. For example, the relative importance of each individual BiOp source to the ultimate management decision is unknown, inherently difficult to measure, and likely unequal across listing decisions. However, it is likely that BiOp decisions are based on cited sources (and not sources excluded from the bibliography), so analyzing characteristics of bibliographies remains a feasible and appropriate way of understanding science use. Moreover, the proportion of cases lost and the authorship affiliation diversity metrics speak more directly to how well science is used: courts take into account the quality of science and the manner in which it is used (*Home Builders Ass'n of Northern*

California v. US Fish and Wildlife Service, 2003) and high authorship affiliation diversity is associated with a clear connection between biological data and management decisions (Gerber & Schultz, 2001).

The finding that one agency does not lose more regularly in court than the other on BAS grounds may be unsurprising because the courts often defer to agency discretion on what constitutes BAS (*Chevron U.S.A., Inc. v. Natural Resource Defense Council, Inc.*, 1984). In addition, BAS may cover a wide breadth of science type and quality, from expert opinion to published scientific journal articles. While some listed species are charismatic and well represented in the academic literature, such as the Southern Resident Killer Whales (*Orcinus orca*), others are obscure and under-represented in the literature, such as the Delhi Sands flower-loving fly (*Rhaphiomidas terminatus abdominalis*). Searches of these species names on the Thomson Reuters Web of Science database (Thomson Reuters, 2015) produced 1329 articles for the whale and only four articles for the fly. Yet if this is all that is available, these two different literatures may both serve as the BAS. In other words, the NOAA may be using “better” science (in the form of a more thorough literature review) from a scientific perspective but not necessarily from a legal perspective.

Of the quality scientific journal articles cited by each agency, one agency did not rely on more high-impact journal articles than the other, as noted in the lack of difference in the mean log-transformed EF value of the BiOps. Neither agency relied more heavily on scientific and professional sources than the other, according to the framework by Jennings and Hall (2012). However, this finding relies on the framework’s definition of scientific and professional sources, which includes sources like books and reports that are not always governed by rigorous scientific values. To understand whether one agency uses more high-quality scientific journal articles, the

proportion of sources with EF values might be more telling. The NOAA did outcompete the FWS on this metric and cited more references in bibliographies, suggesting that the NOAA BiOps entail more thorough literature reviews and include more high-quality scientific journal articles than the FWS BiOps. This could also mean that species under the FWS jurisdiction are not as well studied as those under the NOAA jurisdiction, and the FWS must make decisions on more sparse primary scientific data.

Gehring and Ruffing (2008) present a framework for analyzing endangered species decisions that classifies the use of objective information and political interests as a zero sum game. For example, if political administration changes affected one agency's annual listing frequency more than the other, their analysis suggests that politics influence science-use differently between the two agencies. Stinchcombe (2000) found strong evidence that politics likely play a role in ESA listings, despite the legal mandate to base listings solely on the BAS, and my results show this result intensified over the years subsequent to that study. Political influence appears likely to explain the lower annual listing frequencies in Republican years than in Democratic years and in Bush administration years than in non-Bush administration years by both agencies combined. When trying to understand whether one agency better buffers against political administration changes than the other, the picture becomes less clear. Neither agency was more affected by changes in Republican and Democratic administrations, but the FWS was more affected than the NOAA by the Bush administration. This finding could suggest that the NOAA better buffers its scientific infrastructure to this particular political administration than the FWS, but is likely also due to the small sample size of the NOAA listing decisions compared to those of the FWS. Future NOAA listing decisions will improve our ability to detect and quantify political influence on listing decisions.

Future research on this topic would benefit from more direct metrics of information use in order to better understand the quality of both the science sources used and the way such science is used under the ESA. Furthermore, measuring the changes in science quality over time with respect to political administrations or significant historical events such as the termination of the NBS may shed more light on the factors that govern agency science use.

Differences in Agency Budget, Structure, and History

Although the FWS and NOAA share regulatory space in implementing the ESA, the agencies differ in significant ways that could affect how the agencies use science. For example, the FWS manages more than 15 times as many species as the NOAA on a similar budget—the 2012 FWS budget for endangered species management was \$161 million and the 2012 NOAA budget for the Office of Protected Resources (in charge of ESA and MMPA implementation) was \$174 million (USFWS, 2013; NOAA Fisheries, 2013). Second, the NOAA conducts internal research at regional science centers that are geographically and administratively separate from regional regulatory offices (NOAA Fisheries, 2004). The FWS is separated into regional centers like the NOAA but does not have comparable science centers, suggesting that the FWS does not separate the science and management branches as clearly through agency structure (FWS, 2014). Strong management input at early stages of scientific research may function as a form of regulatory capture, where the agency acts to satisfy the interests of powerful interest groups instead of the public (Helm, 2006). Third, the FWS lost much of its internal science force to the Biological Research Division (BRD) of the United States Geological Survey (USGS) during the rise and fall of the National Biological Survey (NBS) in the 1990s (Wagner, 1999). This event gutted the FWS research force and may have changed the way the agency did science in the years that followed, whereas the NOAA was unaffected by this event. As the lead scientific

research agency for the DOI, the USGS continues to conduct endangered species research to aid the FWS in ESA implementation (Dresler et al., 2004). These agency differences may form the mechanisms that led to my finding of a systematic difference in science use between the agencies.

Policy Recommendations

Differences between the agencies, particularly the discrepancies in dollars-per-managed-species, strongly suggest that the NOAA has better capacity to produce and use science. In light of my finding that the NOAA uses better science than the FWS, I make three policy recommendations concerning increased coordination, separation of science and management, and transparency.

Freeman & Rossi (2000) suggest that coordination is often the best route to improved implementation of environmental statutes when agencies share regulatory space. The FWS and NOAA undergo many of the described forms of consultation, a key method of agency coordination, but one form that could benefit the agencies is the establishment of concurrence requirements regarding the definition of BAS as part of an interagency consultation (Freeman & Rossi, 2012). The agencies would benefit by combining forces to create a framework definition of BAS, which could take the form of a contingency plan depending on the availability of scientific data. For example, if copious data exist on a species' biology, personal communication or an unpublished master's thesis may not be necessary nor suffice as BAS. However, if limited data exists on a species' biology, these same sources may prove to be the BAS. Greater detail and transparency in defining the BAS could help reduce high litigation costs (Baur & Irvin, 2010) by helping agencies check their boxes publically and help ensure that the science used is the BAS.

I first intended to use the Status Review, an internal gray document at the NOAA that summarizes the BAS on a species prior to the listing decision and any management input, to compare bibliographies produced by each agency. I could not find a comparable FWS document, suggesting that either the agency does not produce one or does not make one public in conducting a status review to determine whether listing is warranted. By sheltering science from management input, the Status Review documents may allow the NOAA to consider a greater breadth of science and allow for scientists to highlight the best science using scientific standards. This mirrors the agency's structure of separate management-focused regional offices and science centers. I suggest that this is an underlying root of better science use—science that is close enough to management to be relevant, but far enough to be guided by the norms of scientific research instead of parochial political interests (Gehring & Ruffing, 2008; *Western Watersheds Project v. Kempthorne*, 2008). Through interagency consultation, the NOAA could help the FWS establish a status review procedure that better shields the science from management input before the science makes it to the table for discussion, because the ESA does not provide guidelines for how to conduct the status review (*Center for Biological Diversity v. Badgley*, 2001).

Lastly, in addition to these recommendations that emerge from comparing the agencies, I recommend increased access to, and transparency of, bibliographies used in decision-making. Originally, I intended to analyze bibliographies of listing decisions, not BiOps. Despite the listing decisions published in the Federal Register stating that the literature cited sections are stored at regulations.gov or on the agency's regional office website, I could not find these sections for most listing decisions. This information needs to be publically available, as it is claimed to be, to allow access to the science used and to provide adequate transparency for public involvement (Kelly, 2010). Bibliographies, in scientific disciplines and elsewhere, allow

for accountability of claims and those in BiOps should not be exempt from this defining characteristic of bibliographies, particularly because bibliographies have served as points of contention in ESA cases (*Miccosukee Tribe of Indians of Florida v. US*, 2009; *Conservation Congress v. Finley*, 2012).

I emphasize that this is not a study intending to shame either agency, nor is it intended to cause the agencies to adjust their practices only to maximize their performance according to metrics like those presented here. On the contrary, I hope to illuminate the many forces that influence science use, many of which the agencies do not have control over, in order to focus efforts on improving science use. Both agencies are under intense political pressure and stretched thin on limited budgets. If the agencies are not using good science, it is not necessarily because they don't intend to.

Conclusion

I found that the NOAA systematically uses better science than the FWS. This difference, in context of the agencies' differing budgets, structures, and histories, points to increased coordination, transparency, and separation of science and management interests as a way to improve the quality of science used in ESA decision-making.

It is unlikely that a single environmental law can curb the causes of the sixth mass extinction because the causes are global, diffuse, and often incurred by different entities than those that pay the costs. However, the ESA serves as the only federal legal tool in the United States for directly conserving biodiversity and as a model for understanding the science-policy interface in environmental law, two crucial goals to a habitable and sustainable future.

Literature Cited

- Barnosky, A. D. et al. 2011. Has the Earth's sixth mass extinction already arrived? *Nature* **471**:51–57.
- Baur, D. C., and W. R. Irvin. 2010. *Endangered Species Act: Law, Policy, and Perspectives*. Center for Biological Diversity v. Badgley. 2001. Page 844399 WestLaw.
- Center For Native Ecosystems v. US Fish and Wildlife Service. 2011. Page 1199 Federal Supplement, 2nd Series.
- Chevron U.S.A., Inc. v. Natural Resource Defense Council, Inc. 1984. Page 837 United States Reports.
- Conservation Congress v. Finley. 2012. Page 2989133 WestLaw.
- Corn, M. L., K. Alexander, and E. H. Buck. 2013. The Endangered Species Act and “Sound Science.” Congressional Research Service. Available from <https://www.fas.org/sgp/crs/misc/RL32992.pdf> (accessed April 17, 2015).
- Doremus, H. 2001. Adaptive Management, the Endangered Species Act, and the Institutional Challenges of New Age Environmental Protection. *Washburn LJ* **41**:50.
- Doremus, H. 2004. Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate. *The. Env'tl. L.* **34**:397.
- Doremus, H., and A. D. Tarlock. 2005. Science, judgment, and controversy in natural resource regulation. *Pub. Land & Resources L. Rev.* **26**:1.
- Dresler, P. V., D. L. James, P. H. Geissler, T. M. Bartish, and J. Coyle. 2004. Strategic Plan for the U.S. Geological Survey Status and Trends of Biological Resources Program: 2004-2009. USGS, Biological Resources Discipline. Available from http://www.usgs.gov/ecosystems/status_trends/strategic_plan.pdf (accessed May 9, 2015).
- Eaton, J. P., J. C. Ward, A. Kumar, and P. H. Reingen. 1999. Structural Analysis of Co-Author Relationships and Author Productivity in Selected Outlets for Consumer Behavior Research. *Journal of Consumer Psychology* **8**:39–59.
- Elliott, E. D. 2008. Portage strategies for adapting environmental law and policy during a logjam era. *NYU Env'tl. LJ* **17**:24.
- Endangered Species Act of 1973. 1973. 16 U.S.C. § 1531-1544.
- Fiorino, D. J. 2001. Environmental Policy As Learning: A New View of an Old Landscape. *Public Administration Review* **61**:322–334.
- Freeman, J., and J. Rossi. 2012. Agency coordination in shared regulatory space. *Harvard Law Review* **125**. Available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1778363 (accessed March 13, 2015).
- FWS. 2014. USFWS Organizational Chart. Available from <http://www.fws.gov/offices/FWS-org-chart-06-2014.pdf> (accessed April 27, 2015).
- Gehring, T., and E. Ruffing. 2008. When arguments prevail over power: the CITES procedure for the listing of endangered species. *Global Environmental Politics* **8**:123–148.
- Gerber, L. R., and C. B. Schultz. 2001. Authorship and the use of biological information in endangered species recovery plans. *Conservation biology* **15**:1308–1314.
- Goldfinch, S., T. Dale, and K. DeRouen. 2003. Science from the periphery: Collaboration, networks and 'Periphery Effects' in the citation of New Zealand Crown Research Institutes articles, 1995-2000. *Scientometrics* **57**:321–337.

- Greenpeace American Oceans Campaign v. National Marine Fisheries Service. 2002. Page 1181 Federal Supplement, 2nd Series.
- Helm, D. 2006. Regulatory Reform, Capture, and the Regulatory Burden. *Oxford Review of Economic Policy* **22**:169–185.
- Home Builders Ass’n of Northern California v. US Fish and Wildlife Service. 2003. Page 1197 Federal Supplement, Second Series.
- Intertribal Sinkiyone Wilderness Council v. National Marine Fisheries Service. 2013. Page 988 Federal Supplement, 2nd Series.
- Jennings, E. T., and J. L. Hall. 2012. Evidence-Based Practice and the Use of Information in State Agency Decision Making. *Journal of Public Administration Research and Theory* **22**:245–266.
- Kelly, R. P. 2010. The use of population genetics in Endangered Species Act listing decisions. *Ecology Law Quarterly* **37**:1107.
- Klyza, C. M., and D. J. Sousa. 2008. *American Environmental Policy, 1990-2006 : Beyond Gridlock*. MIT Press, Cambridge, MA, USA. Available from <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10209889> (accessed May 9, 2015).
- Lambright, W. H. 2008. Government and science: A troubled, critical relationship and what can be done about it. *Public Administration Review* **68**:5–18.
- Liao, C. H. 2011. How to improve research quality? Examining the impacts of collaboration intensity and member diversity in collaboration networks. *Scientometrics* **86**:747–761.
- McCauley, D. J., M. L. Pinsky, S. R. Palumbi, J. A. Estes, F. H. Joyce, and R. R. Warner. 2015. Marine defaunation: Animal loss in the global ocean. *Science* **347**:1255641.
- Miccosukee Tribe of Indians of Fla. v. United States. 2009. Page 1257 Federal Reporter, 3rd Series.
- NOAA Fisheries. 2004. Operating Agreement Between Regional Offices and Regional Science Centers: Guidelines. Available from <http://www.nmfs.noaa.gov/op/pds/documents/30/119/30-119-01.pdf> (accessed April 17, 2015).
- NOAA Fisheries. 2013, April 23. Overview of NOAA Fisheries’ Budgets for Fiscal 2013 & 2014: Presentation to NOAA Fisheries’ Stakeholders.
- NOAA Fisheries. (n.d.). Endangered Species Act Policies, Guidance, and Regulations :: NOAA Fisheries. Available from <http://www.nmfs.noaa.gov/pr/laws/esa/policies.htm> (accessed April 27, 2015).
- Oksanen, J. et al. 2013. Package “vegan.” Community ecology package, version **2**. Available from <http://cran.ism.ac.jp/web/packages/vegan/vegan.pdf> (accessed May 12, 2015).
- Protect our Communities Foundation v. Ashe. 2013. Page 6121421 WestLaw.
- R Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2012. ISBN 3-900051-07-0.
- Ruhl, J. B. 2009. Who Needs Congress? An Agenda for Administrative Reform of the Endangered Species Act. SSRN Scholarly Paper ID 1354712. Social Science Research Network, Rochester, NY. Available from <http://papers.ssrn.com/abstract=1354712> (accessed January 15, 2015).
- Stinchcombe, J. R. 2000. US Endangered species management: the influence of politics. *Endangered Species Update* **17**:118–121.

- Testa, J. 2012. The Thomson Reuters journal selection process. John Wiley & Sons, Ltd. Available from <http://www.journal.canadae.biz/ebusiness-technology/wp-content/uploads/2009/08/Template-Thomson-Selection.doc> (accessed April 19, 2015).
- Thomson Reuters. (n.d.). Available from <http://login.webofknowledge.com/error/Error?PathInfo=%2F&Alias=WOK5&Domain=.webofknowledge.com&TimerValue=30000&Src=SIDCheck&ErrorCode=Server.sessionNotFound&RouterURL=http%3A%2F%2Fwww.webofknowledge.com%2F&Error=Session+not+found%3A+SID%3D1BzWov4hfd9FH7h5Z6H+NodeID%3D1B> (accessed May 9, 2015).
- Title 50 e-C.F.R § 17.11. February 1, 2015. Available from <http://www.ecfr.gov/cgi-bin/text-idx?rgn=div8&node=50:2.0.1.1.1.2.1.1>
- USFWS. 2013. Federal and State Endangered and Threatened Species Expenditures: Fiscal Year 2012. Available from <http://www.fws.gov/endangered/esa-library/pdf/2012.EXP.FINAL.pdf>.
- USFWS, and NOAA Fisheries. 1994, July 1. Endangered and threatened wildlife and plants: Notice of interagency cooperative policy on information standards under the Endangered Species Act. Office of the Federal Register, National Archives and Records Administration. Available from <http://www.gpo.gov/fdsys/granule/FR-1994-07-01/94-16022>.
- Wagner, F. H. 1999. Whatever happened to the National Biological Survey? *BioScience* **49**:219–222.
- Western Watersheds Project v. Kempthorne. 2008. Page 4649130 WestLaw.
- West, J. D., T. C. Bergstrom, and C. T. Bergstrom. 2010. The Eigenfactor Metrics™: A network approach to assessing scholarly journals. *College & Research Libraries* **71**:236–244.